# METAL CASTING

The present invention relates to a method and apparatus for producing a metal casting, particularly but not exclusively for the jewellery industry.

There are many different kinds of casting processes, but not all are suited to the high standards required by the jewellery industry. Investment casting and centrifugal casting are two procedures which have been widely used to produce jewellery because castings with precise dimensions and good surfaces are achievable. However, even with these procedures there are problems, for example porosity and other defects arising in castings due to surface tension phenomenon and the decomposition of the mould materials. Although advanced casting techniques such as computer controlled 'pressure over vacuum' castings have the potential to overcome certain problems, they are relatively expensive and in any event are not suitable for the more reactive jewellery compositions.

An object of the present invention is to provide a method and apparatus which is capable of overcoming or at

least ameliorating some of the difficulties encountered especially in the jewellery industry when casting using conventional processes and apparatus.

In accordance with a first aspect of the present invention, there is provided a method for producing a metal casting, comprising: providing a metal in a crucible; melting the metal in the crucible, under an inert atmosphere using an arc from an electrode; and releasing the molten metal into a mould.

The arc may produce a plasma temperature of around 10,000°C, and is thus able to heat the metal very rapidly and at least to a degree sufficient to melt all metals.

The metal in the crucible may comprise at least two parts of different compositions. For example, one part may comprise a gold-rich alloy and another part may comprise an aluminium-rich alloy. The two parts may be alloyed together in the crucible. Alloying *in situ* may require stirring the molten metal in the crucible to give a homogenous melt. Stirring may be achieved by establishing relative movement between the arc and the crucible, possibly by oscillating the electrode. Preferably, the electrode does not contact the molten metal.

The molten metal may also be agitated in the crucible by supplying to the electrode a pulsating alternating current of varying frequency, e.g., 0-50 HZ. Such current agitation encourages homogeneity in the molten metal. It may be advantageous to superimpose a direct current bias to the alternating current in order to shift the balance. By

adding a positive direct current bias, the arc is predominantly positive which may clean the molten metal. Such electric cleaning (ion-bombardment) enables use of materials with inherent oxides, for example aluminium alloy. It could also be used to recycle contaminated old jewellery. Alternatively, by introducing a negative direct current bias, the arc will predominantly be negative which may give rise to greater heating of the metal in the crucible.

The method for producing a metal casting may further comprise varying the pressure of the inert atmosphere during melting. By exerting positive or negative gas pressures on the molten metal, it is possible to lower surface tensions or remove trapped gases. During use of negative gas pressures to remove trapped gases, it is desirable to remove evolving vapours possibly by maintaining a supply of inert gas to purge the inert atmosphere around the molten metal. In addition to exerting a positive pressure on the molten metal, a negative pressure (suction) may be applied to the mould during pouring of the molten metal. Such a pressure differential may encourage molten metal flow from the crucible to the mould.

According to a second aspect of the present invention, there is provided apparatus for producing a metal casting, comprising a crucible, means for establishing an inert atmosphere around metal in the crucible, an electrode, means for supplying electricity to the electrode to

generate an arc for melting metal in the crucible, and a mould for receiving molten metal from the crucible.

The inert atmosphere establishing means may simply comprise a flow of inert gas directed from the electrode towards metal in the crucible. The flow should be sufficient to establish an inert gas shield around metal in the crucible and preferably from the electrode to metal in the crucible. Alternatively, the inert atmosphere establishing means may include a pressure chamber in which the electrode and metal in the crucible are located. The pressure chamber enables the pressure of the inert atmosphere to be decreased for removing trapped gases in the molten metal, and subsequently increased to lower molten metal surface tension. The pressure chamber may have means for changing the inert atmosphere without altering gas pressure in the pressure chamber. For example, an outgoing flow of inert gas contaminated with vapours evolved from the molten metal may be matched by an incoming flow of uncontaminated inert gas.

The apparatus may further comprise a conduit communicating between the crucible and the mould, and having a valve for regulating molten metal flow through the conduit. The apparatus may be arranged with the crucible above the mould so that molten metal flow through the conduit is aided by gravity, the molten metal flow through the conduit may further be encouraged by establishing a pressure differential across the valve. For example, a vacuum pump may be used to lower gas pressure in the mould

prior to opening the valve.

The crucible or the mould may be of graphite. A graphite crucible would be able to carry a high current and at the same time additional heating and subsequently some cooling by thermal conduction would be possible. By the same token, a graphite mould would facilitate preheating of the mould before molten metal is introduced into it. The graphite mould may be heated by electric heating elements. Graphite is much less reactive than certain other mould materials, and thus is compatible with the more reactive jewellery compositions.

Other features of both aspects of the present invention are set out in the appended dependent claims, to which reference should now be made.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic showing manual apparatus embodying the present invention; and

Figure 2 is a section of automated apparatus embodying the present invention.

Figure 1 shows schematically manual apparatus 10 for producing cast jewellery, comprising a tungsten inert gas (TIG) hand torch 12, a graphite crucible 14, and a graphite mould 16. The TIG hand torch 12 has a tungsten electrode 20 which produces an arc (not shown) within an inert gas shield 22 when supplied with high frequency alternating current. The inert gas shield 22 is provided by a flow of

inert gas directed through the TIG hand torch 12 and beyond the electrode 20. The graphite crucible 14 communicates with the mould 16 through conduit 24 when opened by graphite tap rod 26.

A metal sample 28 to be cast, or a mixture of metal samples 28 to be alloyed and then cast, are placed in the crucible 14. The tap rod 26 is positioned to seal off the conduit 24, blocking communication between the crucible 14 and the mould 16. The TIG hand torch 12 is energized by the high frequency alternating current supply 30. The arc thus generated strikes the sample(s) 28 and rapidly produces molten metal. The molten metal is agitated by pulsing of the arc caused by the alternating current. The balance of alternating current is adjusted by superimposing a direct current supply 32. The DC supply 32 may be switched between positive and negative, to make respectively the alternating current supplied to the electrode 20 either predominantly positive or predominantly negative. The molten metal is further agitated by a stirring action imparted by oscillating the TIG hand torch 12; the electrode 20 does not contact the molten metal.

The graphite mould 16 is preheated by heating elements 34. The pressure of gas in the mould 16 is reduced by a vacuum unit 36 which withdraws gas through suction hole 38. When the molten metal is ready for casting, tap rod 26 is moved to allow molten metal to flow through conduit 24 into the mould 16 where it is allowed to cool.

Figure 2 shows a section of an automated jewellery

casting apparatus 50. Features of the apparatus 50 which are in common with the manual apparatus 10 of figure 1 have been given the same reference numerals. In the apparatus 50, the tungsten electrode 20 of a pulsating arc torch 52 and the crucible 14 are mounted in a pressure chamber 54 which is connected to vacuum pump 56 through coolant unit 58. The pressure chamber 54 is supplied with inert gas through supply hose 60.

The pulsating arc torch 52 is connected to a motorised cam which in use causes the electrode 20 to oscillate in such a way that stirring of molten metal in the crucible 14 is achieved. The separation of the electrode 20 from the crucible 14 is varied by adjusting the length of support struts 64.

The operating procedure of the automated jewellery casting apparatus 50 will now be described:

1) Alloying elements are placed in the graphite crucible 14.

2) The pressure chamber 54 is sealed.

3) The graphite mould 16 is preheated (the graphite crucible 14 may also be preheated).

4) The pressure chamber 54 is purged with argon inert gas.

5) The pressure of the gas in the pressure chamber 54 is reduced.

6) The gas pressure in the pressure chamber 54 is balanced at between 10 and $10^{-1}$ torr, with the graphite mould 16 at about 300°C.

7) The AC pulsed arc (argon-tungsten) is started using the high frequency supply.

8) The motorised cam 62 is started to oscillate the torch 52.

9) The alloying elements are melted in the crucible, cleaned using the predominantly positive (DC biased) arc using ion bombardment to break up intermetallic oxides and the like, and homogenized by stirring and agitating.

10) In the negative-pressure argon atmosphere of the chamber, impurities and oxides of the alloying elements are transformed into vapours and removed by continuous action of the unit 56.

11) The purified and homogenized molten alloy is then cast into the graphite mould 16 (pre-purged with inert argon). To improve molten metal flow into the mould 16, the pressure in the chamber 54 is increased and at the same time, the pressure in the mould 16 is decreased by suction through hole 38.

12) The cast metal is allowed to cool.